Some Experiments touching Animals, *made in the* Air-pump *by the Perſons formerly mentioned,* viz. *Monſieur* Hugens *and M.* Papin ||.

|| *Compare* Numb. 62 *and* 63 *of theſe Tracts, where many Experiments of this kind, made by Mr.* Boyle, *are recorded.*

One day I included in the *vacuum* an *Inſect* which reſembles a *Beetle*, but is a little bigger; and when I perceived it to appear dead, I gave it Air again, and it ſoon after recovered. Then I put it in the *vacuum* again, and having left it there, for an hour, I readmitted the Air, and found, that the Inſect needed then much more time to recover. I included it there the third time, and having left it there two daies, I gave it Air again, and ſaw, it needed above ten hours before it began to ſtir again; yet it recovered well enough this time: But having put it in again the fourth time, and left it there eight daies, it would never ſtir again.

Intending to try the like upon a *Butterfly*, I ſaw, that when I readmitted Air to it, that the top of its back, which before was much ſwelled, did fall-in more than it ſhould, and the Inſect would not recover.

I alſo killed in the *vacuum* many Animals that breath, as *Birds*, *Mice*, *Rats*, *Rabbets*, *Cats*; and ſome of them I recovered by quickly giving them Air again, before the Engine was quite exhauſted; but I never ſaw any of them revive, that had been in a perfect *vacuum*.

Monſieur *Guide* did make frequent Diſſections of ſuch Animals as we had thus killed, and obſerved among other things, that their Lungs fell to the bottom in water. In a little Book of his, printed of this Subject, he hath declared his opinion concerning this Experiment. He being a lover of truth, I am perſwaded, he will not take it amiſs, if I deliver my ſentiment about it, which I think more probable than his.

He ſaith, that the Solidity or Cloſeneſs of the Lungs of Animals that have died in *vacuo*, comes from hence, that the Blood, which is propelled into the Lungs by the *Vena arterioſa*, doth ſo ſtrongly preſs the *bronchi* of the *Arteria aſpera*, that it expreſſes the Air out of them, and glues as 'twere their ſides to one another. But for my part, I do not believe, that the Blood of the *vena arterioſa* can thus compreſs thoſe *bronchi*, becauſe that the ſaid blood is incloſed in its veſſels, that keep and hinder it from compreſſing others. Yet I am not ignorant, that the things that are included in the *Oeſophagus* do indeed compreſs the *aſpera arreria*, and that the *aſpera arteria* by being fill'd compreſſes alſo the *Oeſophagus*, upon the account of the ſcituation of theſe two conduits. But it appears not at all, that the ſmalleſt ramifications of thoſe *bronchi*, and of the *vena arterioſa*, are ſcituate in the ſame manner; for, the *bronchi* being harder than the *arterial vein*, they will compreſs *it* more eaſily, than be compreſſed *by it*; and ſo, if you ſhould blow them up with Bellows, they would glue the ſides of that vein together, and hinder the Circulation: Which is directly contrary to the Experiment; as M. *Guide* himſelf obſerveth.

It is therefore far more probable, that, if the Lungs be compreſſed, that compreſſion be made by the *pleura*, which may be ſwelled *within* the Breaſt, as the skin is ſwelled *without*. But it is not neceſſary, that the Lungs be *compreſſed* in *vacuo*, to make them ſubſide in water. For I have divers times put pieces of Lungs and whole Lungs in the *vacuum*, and they remained there extremely ſwelled; but as ſoon as the Air was again intromitted, they became very flat and red, and ſunk to the bottom in water. Which ſhews, that 'tis ſufficient for getting the Air out of the Lungs, to render them cloſe and red; and I have not been able to produce this effect but by means of the Exhauſting Engin. For, I have left Lungs a whole night between two plates with a great weight upon them, to endeavour to expreſs the Air out of them, but it would not ſucceed, and thoſe Lungs did ſtill float upon the water. I have alſo tried to make the Air re-enter into the Lungs after I had rendred them ſolid in the Engin, and that I fouud very eaſie; for, drawing them out from the bottom of the water, I did blow into the *aſpera arteria*; and the Lungs ſwelled again and reſumed their ordinary colour, and floated on the water. And this is that which befalls the Lungs of *Infants* new-born.

Promiſcuous Experiments made in the Air-pump *likewiſe, by the ſame Perſons.*

WHen I began firſt to keep Receivers void of Air, after the manner above-recited, I made uſe of ***Eels-skins*** to apply them cloſe to the Cover. But I found them not proper for things that are intended to be conſerved a long time, becauſe by drying they grow ſpringy, and this ſpring is capable to raiſe the whole pillar of Air that preſſes the Receiver againſt its Cover; and ſo the Air gets in between, and fills the ſpace exhauſted.

Afterwards I employed ***Mutton-skin***; but that ſticks yet leſs cloſe than an Eel-skin: For, aſſoon as the external Air comes to preſs upon it, it makes all the water, which wetteth the skin that ſtands over without, enter into the emptied Receiver, and you may ſee little drops of water coming out of the pores of the skin that is under the Receiver; and after the water is all entred, the Air quickly gets in the ſame way.

At length I took a ***Lambskin***, and by means thereof I have kept Receivers empty eight daies together, and never perceived it fail. Yet, for greater ſecurity, I do put ***Turpentine*** round about ſuch Receivers as I mean to keep ſtaunch a long time. Mean while, this difference betwixt the skins of Mutton and Lambs is ſomewhat remarkable, and confirms what Phyſicians ſay of the different Couſtitution of bodies in Youth and old Age. I have afterwards found, that ***Paper*** wetted ſerves as well as a Lambskin; but you muſt put Turpentine about it before it be dry.

One day I cover'd a Receiver, whoſe fourth part was fill'd with water, and the reſt all empty. I put it over the flame of a Candle, and ſaw, that the water boiled very quickly, yet the glaſs not much heated; ſo that the water boiled near a quarter of an hour with a great ebullition, and the glaſs was no more than tepid. I then took it away from the flame, and ſaw, that the water continued a very great while boiling, and that it began again from time to time. I then believed, that the vapours, which had been raiſed into the Air, were recondenſed by the cold, and that that made the hot water bubble up, as water uſually doth when 'tis put into the Engine, and the Air that preſſes it exhauſted. Mean time, I have ſince made the ſame Experiment with a *Gage*, and I did not perceive, that all the bubbles that iſſued out of the water, made the Mercury riſe to ſenſe.

After this, I left my Receiver expoſed to the *Froſt*, and I found, that the Ice which was made therein was not yet quite free from bubbles, though the water thereof had boiled in the *vacuum*, which, one would think, ſhould have driven out all the Air: Yet the bubbles were there far leſs numerous than in Ice made of ordinary water. I perceived not, that the Quickſilver was much riſen in the *Gage*. Afterwards I melted this Ice, and put the water abroad to freez again, ſtill without taking it out of the *vacuum*, and I found, that this ſecond time it was very much freer from bubbles. The Glaſs did not break; but becauſe it was ſomewhat conical, we could not know, whether it remained whole upon the account of its *figure*, or becauſe that the water, which was frozen within, was freed of Air: And I could not make the Experiment with glaſſes of another figure, becauſe the Froſt did ceaſe.

After this, I made *Spirit of Wine* boil *in vacuo* in the ſame manner I did the Water; and I ſaw, that it boiled much ſooner. It made the Mercury riſe about an inch in the *Gage*. Then I took it from the fire, and ſaw it continue in its boiling; and even ſinking the Receiver into cold water, it thereupon boiled much more ſtrongly. One would think, this proceeded from an *Antiperiſtaſis*; but we have more ground to ſay, it came from hence, that the vapours of the Spirit were condenſed, and ſo made the Receiver more empty; which is ſufficient to make the Spirit of Wine boil, even though it were not hot. The Quickſilver did in two hours ſubſide again, to near half a line as low as it had been. Then I put the Receiver over the flame again, and made the Mercury riſe more than two inches; but then the Receiver cracked.

One day I took a *Tube of Plaſter* of *Paris*, open at one end, and cloſe at the other. I applied the open end to the cement as I was wont to do Receivers; and I ſaw it was not poſſible thus to exhauſt it, becauſe the *Air* did eaſily paſs *through* the Plaſter. I put therefore a Tube of Iron on the Engin, ſo as having filled it with water, the Tube of Plaſter was cover'd therewith; and then having cauſed the Pump to be plied, I found, that the *Water* did paſs *as eaſily* through the ſaid Plaſter. I therefore cover'd it with Venice-Turpentine inſtead of water, and then I ſaw, that it evacuated very well, and that nothing paſſed through it for the ſpace of two hours. Then I took ſome Oyl very hot, and poured it over the Turpentine, which did melt by this heat and paſſed through the Plaſter. Then I took off this Tube which was ſo pervaded by the Turpentine, and I ſaw, that that had made it tranſparent. Which effect is pretty like, and is to be explicated in the ſame manner as, [that of the little Stone called *Oculus mundi.* Thus we may be aſſiſted by the *Weight of the Air* to make divers ſorts of Glues penetrate Plaſter, baked Earth, Wood, &c. And poſſibly thoſe, who ſhall make a good number of ſuch trials, will find their labour and pains recompenced, by giving to thoſe materials ſuch properties, as they never had before.

I did alſo put ſome *Eggs* in the *vacuum*, and one day I ſaw one of them break, which I had put in a ſmall Receiver. It burſt upon the very firſt ſuction: But ſince that time I could never make *any* break, though I exhauſted as much as I could thoſe Receivers wherein I had put ſome. You muſt therefore begin to crack them a little before you put them in the *vacuum*, and then they do eaſily break quite, and what is in the Egg riſeth all into a very thick froth. I alſo put ſome of theſe, thus order'd, over the fire, where they boiled very eaſily, not being preſſed by the Air, but they boiled there very long, before it began to appear that they were ſo boiled as to be ready to eat.

All the little bubbles that appear in *Muſtard*, do ſwell and break in *vacuo*, and after that, the Muſtard is ſeen to be without bubbles.

One day I included a *black Ribbon* in the *vacuum*, and then burnt it with a Burning-glaſs. Abundance of ſmoke iſſued out of it, which fell by little and little, and ſo permitted us to ſee the Ribbon plainly; which appeared not at all changed. But after I had returned the Air unto it, and touched it, I found it all turn'd to aſhes.

Another time I cauſed alſo ſome *Gunpowder* to be burnt after the ſame manner; and I was much ſurprized to ſee, that it burnt grain by grain, none of the grains kindled firing thoſe which touched. Another time when the Sun had leſs force, I could not at all kindle the Powder, but I made it only boil and emit ſtore of ſmoke. I had put a *Gage* in the ſame Recipient, by means whereof I obſerved, that all that ſmoke produced no Air; for the Quickſilver did not riſe in the Tube. I noted alſo, that this ſmoak falling upon the Paſt-board, on which I had put the Powder, appeared yellow of the colour of Brimſtone. After that, I took out the Powder that remain'd, being like a black maſs, and having put it upon burning Coals, I ſaw it burned as doth Salt-Peter; and ſo it appear'd, that the ſulphur was almoſt all exhaled.

I was willing to reiterate this Experiment, and I then ſaw, that the Powder, after boiling, fuming, and being kindled grain by grain, (as in the firſt Experiment,) at laſt flaſhes out all at once, when one hath the patience to hold the fire to it with a Burning-glaſs. And when the fumes are grown clearer, you may ſee needles of Saltpeter ſticking to the ſides of the Receiver.

Another time, I put the weight of 12 or 15 *grains* of Powder in a glaſs ſhaped like a Cupping glaſs, capable to hold 14 ounces of water, and having put fire to it, I made the Powder boil and ſmoak as uſually. Afterwards, ſeeing that the corns began to crack very near one after another; I then took away the burning Concave, for fear all ſhould be kindled together: But it was already too late; for, the corns did continue to crack longer than a ſecond of time, and at laſt all kindled, though there was then nothing left to heat them but the fire which they had kept within themſelves. The Receiver was lifted up above a foot high, without breaking.

Another time, I put the weight of 18 *grains* of Powder, together with a *Gage*, into a Receiver holding ſeven pound water; and I ſaw, that the Powder was more difficult to be kindled, than in ſmall Receivers. Yet at length it was kindled altogether, and made the Quickſilver riſe to the height of an inch and a half in the *Gage*; and I am very well aſſured, that all that Air was not come from without; for that part of the Receiver, to which the Cover is applied, had alwaies been under water.

From what I have been relating, it may be concluded, that there is a *fifth* part of Air in Gunpowder; ſuppoſing, as other Experiments do ſhew, that Air is about a *thouſand* times lighter than Water. For, in this Experiment, the Mercury did riſe to the *eighteenth* part of the height where the Air commonly ſuſtains

it;

it; and conſequently the weight of 18 *grains* of Powder did yield Air enough to fill the eighteenth part of a Receiver that contains ſeven pound of water. Now, this eighteenth part contains 49 drachms of water: Wherefore the Air, that takes up an equal ſpace, being 1000 times lighter, weighs $\frac{1}{1000}$ of 49 drachms, which is more than $3\frac{1}{2}$ grains. It follows therefore, that the weight of 18 *grains* of Powder which I employed in my Experiment, contained more than $3\frac{1}{2}$ of Air, which is about the fifth part of eighteen grains.

It may alſo be calculated, how many times this Air hath been compreſſed in the Powder: But this calculation is more uncertain than the former, becauſe we know not, whether this Air took up more or leſs than the fifth part of the ſpace which the Powder poſſeſſed. But yet 'tis certain, that, though it had even taken up *three fourths* of the whole room of the Powder, and that the fourteen grains of the other matter had taken up no more than the one remaining fourth part, ſtill this Air would have been compreſſed about three hundred times. To calculate this, I ſuppoſe, that the ſpace of a Cubic foot can hold only 72 pound of Gunpowder, which do contain more than 14 pound of Air, by the foregoing *calculus*; which quantity of Air is therefore found incloſed in the *three fourths* of a Cubic foot. Now, this ſpace doth uſually contain but about ſix drachms of Air: Wherefore, to make it hold fourteen pound of Air, which is near three hundred times ſix drachms, it muſt needs be, that that Air be compreſſed near three hundred times.

There is reaſon to believe, that this Compreſſion is much greater, becauſe a Cubic foot can hold much more than ſeventy two pound of Powder, and becauſe alſo that the *fifth* part of the weight muſt not, in appearance, poſſeſs alone the *three fourths*, and all the reſt take up no more than *one fourth* of the ſpace poſſeſſed by all the Powder.

I ſhould therefore make no difficulty to believe, that all the effect of Gunpowder comes from the Air which is compreſſed therein, and eſpecially in the Saltpeter; for I have not obſerved, that Brimſtone yields Air. Poſſibly alſo we may find in time, that all other Fulminations, Ebullitions and Fermentations, that make ſuch ſurprizing motions, are nothing elſe but Air compreſſed expanding it ſelf.